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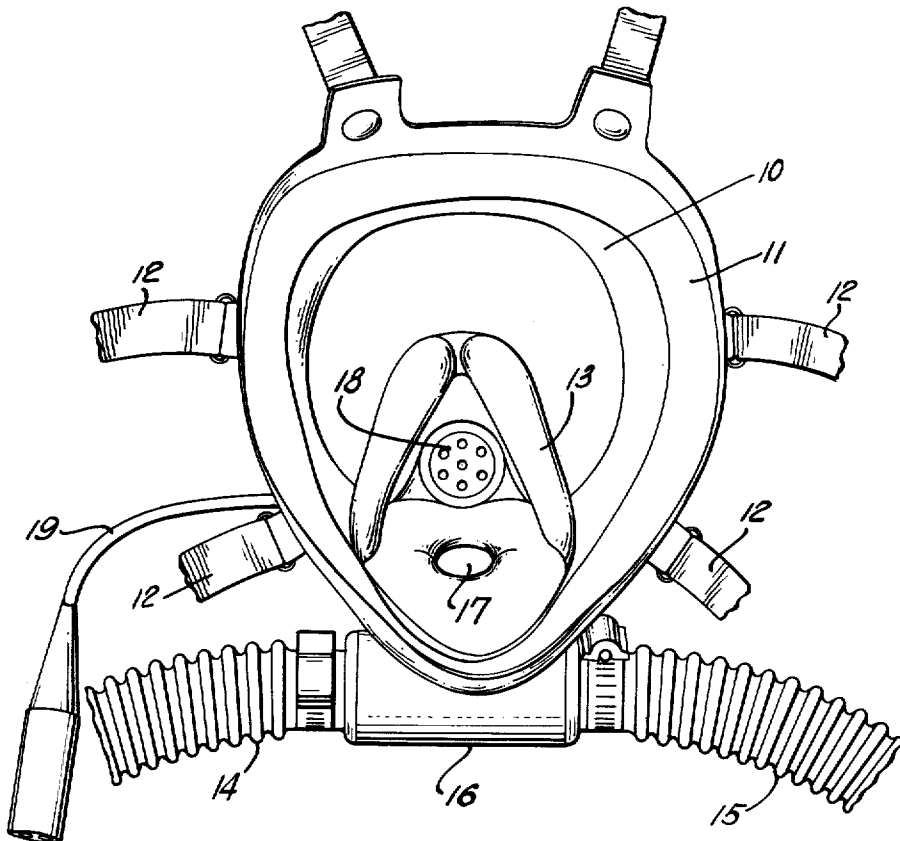
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WATERPROOF INERTIAL TYPE MICROPHONE

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3 Sheets-Sheet 1

Fig. 1.



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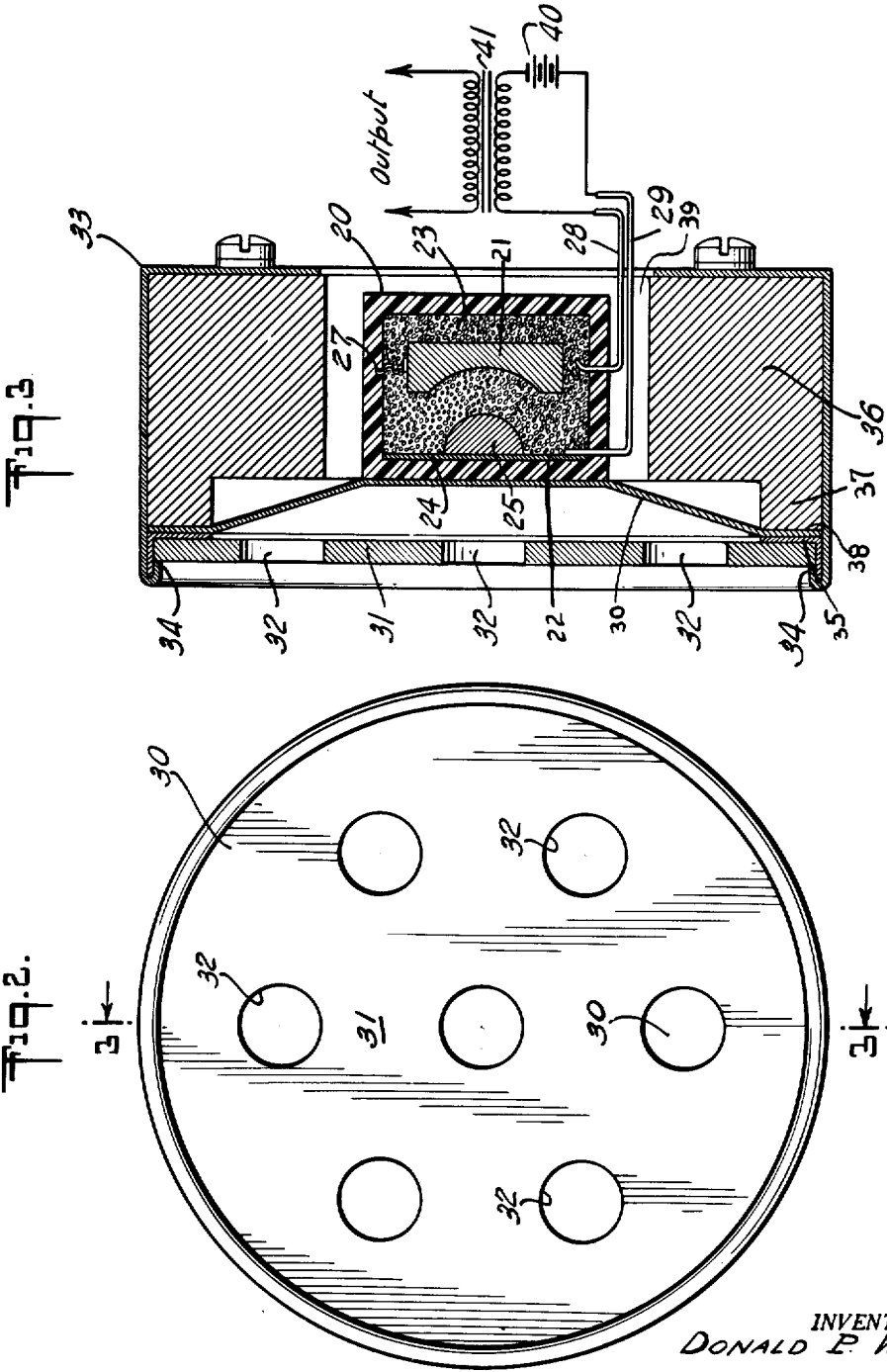
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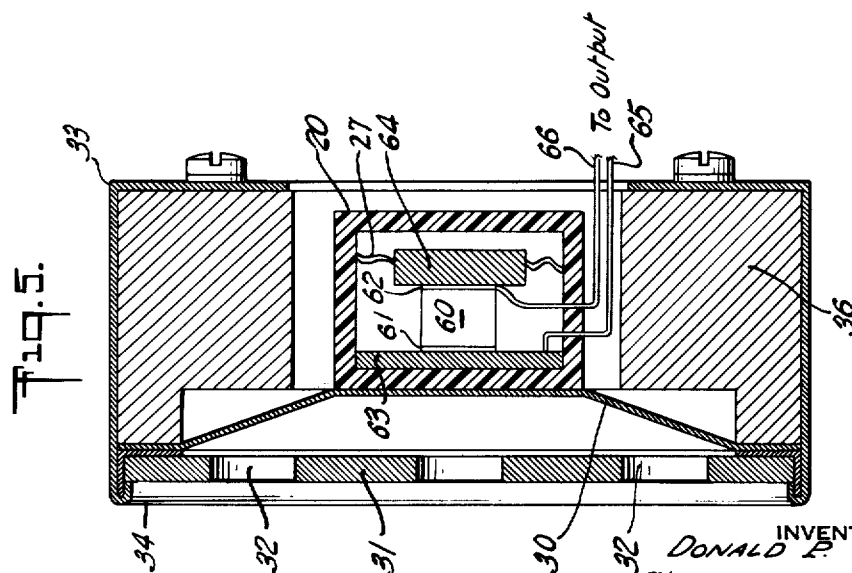
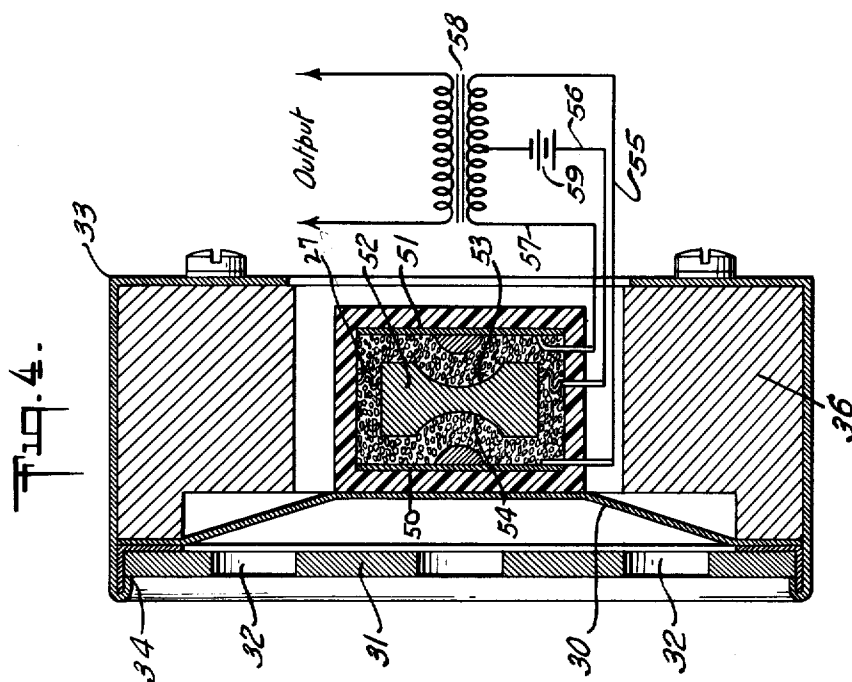
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WATERPROOF INERTIAL TYPE MICROPHONE

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5 Claims. (Cl. 179-122)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates in general to devices for converting acoustical energy into corresponding electrical signals and more particularly to a microphone for use in diving masks.

With advent of increased underwater activity such as submarines and divers the problem of underwater communication has taken on various new aspects. One of these is the use of microphones in the mask of an underwater swimmer. The microphones now in present use are standard microphones which have been adapted for such use. These microphones have been waterproofed and pressure compensated. Unfortunately, however, after exposure to water these microphones lose their watertight integrity and age. Continuous preventive maintenance is required to keep these units from serious loss of sensitivity and undue distortion. Since there are moving parts associated with these microphones and the pressure must be compensated it does not require undue water exposure to hamper their successful operation. In addition to this, these microphones are of a relatively large physical size since they must be both waterproof and pressure compensated. This increased size restricts the vision of the swimmer and results in a large cumbersome mask. Various solutions to the problem have been tried and suggested but they have all proved unsuccessful in one respect or another due in part to the fact in all the cases the solutions have contemplated the redesign of existing microphones which were originally basically not designed for underwater use. Addition of waterproofing and pressure equalization seriously impairs the efficiency of these microphones.

Applicant with his wide experience in underwater problems and the swimmer's environment has approached the problem quite differently by designing an entirely different microphone for meeting the basic requirements of such underwater microphones.

An object of this invention is to provide a small compact, efficient microphone.

Another object is to provide a waterproof microphone for underwater use which is insensitive to static pressure.

A further object is to provide an electrically and mechanically, simple, efficient, inexpensive microphone for use in a swimmer's mask.

Still another object is to provide a small compact microphone that is insensitive to static pressure, waterproof and corrosion resistant.

Other objects and advantages will be apparent from the following description of some embodiments of the invention and the novel features thereof will be particularly pointed out hereinafter in connection with the appended claims.

In the accompanying drawings:

FIG. 1 is a perspective of an underwater swimmer's mask employing an embodiment of this invention;

FIG. 2 is a front elevation of an embodiment of this invention;

FIG. 3 is a cross-sectional plan approximately along line 3-3 of FIG. 2;

FIG. 4 is a cross-sectional plan of another embodiment made in accordance with this invention; and

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FIG. 5 is a cross-sectional plan of still another embodiment made in accordance with this invention.

FIG. 1 clearly illustrates the physical relationship and size of the microphone of this invention with respect to the mask of an underwater swimmer with which it can be used. The mask 10 which is placed over the face of the swimmer and tightly abuts his face along the edge 11 is secured in position by straps 12. The inner portion 13 of the mask forms a cavity which is directly in front of and covers the swimmer's nose and mouth. This inner portion provides a watertight cavity permitting the swimmer to breathe air supplied through hose 14 and to expel air through hose 15. The hoses are connected to a canister 16 which contains a valve allowing the swimmer to both take in and expel air through opening 17 in the mask. In order to communicate, the swimmer must be provided with a transducer as for example a microphone 18, which will convert his speech into corresponding electrical signals that may then be transferred by waterproof cable 19 to any suitable transmitter means. Since in most cases the microphone is exposed to sea water at one time or another such as when the swimmer surfaces and removes his mask the microphone must be waterproof. In fabricating such a microphone in the past, it has been the practice to start with a standard microphone and then proceed to waterproof it. This procedure results in a rather large, bulky unit which requires constant servicing in view of the fact that exposed parts of the microphone are movably mounted and so subject to environmental conditions, such as salt water. A large microphone in addition would obstruct the vision of the swimmer and require a much larger overall mask. The microphone of this invention may be, as is shown, readily mounted within the cavity of the mask without interference either to the swimmer or the mask since it is compact, waterproof and requires very little or no maintenance.

In the embodiment of the invention illustrated in FIGS. 2 and 3 a watertight casing or enclosure 20 of any suitable lightweight pressure resistant and non-corrosive material such as polyester molding, one of a type which is marketed by Du Pont Co. under the trademark "Mylar," or an acrylic resin which is marketed under the trademark "Plexiglas" by the Rohm and Haas Co., or a metal, contains an inertial mass 21, an electrode element 22 and carbon granules 23. The electrode 22 is of electrically conducting material or has its inwardly facing surface coated with an electrically conductive material and supported by the housing so as to be rigidly affixed thereto as for example, by being bonded to a wall of the housing. Although the housing can be of any desired shape it has been found quite satisfactory to have it cylindrical and closed at both ends with the electrode 22 disposed near one end 24. The electrode illustrated in FIG. 3 is a thin strip of metal such as copper and covers the entire inner end wall 24 of the housing although it is only necessary to provide a surface area sufficient to maintain a relatively low resistance path between the electrode and inertial mass through the carbon. The electrode may be fabricated so as to have an approximately centrally located lateral extension in a direction away from the wall 24 or be provided with an electrically conducting hemispheric section 25 which abuts and is electrically connected to the electrode. Spaced from the opposite end wall 26 and from the electrode is an electrically conducting inertial mass 21 of any heavy suitable material such as copper or some other non-conducting material provided one surface is electrically conducting whose mass is substantially large so as to act as an inertia element. The inertial mass is supported within the casing for movement in a direction between the end walls and relative to the end walls 24

and 26 of the housing as for example by springs 27 or any other resilient compliant material which may be anchored to the walls of the housing. The resilient compliant material or spring biases the mass to some relative reference position intermediate of its path of travel so that it may move in either direction away from this reference position relative to the casing. Where the mass and the material employed to movably support the inertial mass is electrically conducting, connection may be made directly thereto as for example wire 28, which is sealed to and passes through the casing and is electrically connected to the spring 27 and thereby provides an external connection to the inertial mass. Where the mass has only a conductive coating the connection must be made to this coating. Likewise wire 29 is connected to electrode 22. The inertial mass 21 is basically circular in cross-section where the housing is cylindrical and disposed coaxial therewith. It may of course assume any shape in cross-section but preferably the same as the casing. The surface of the inertial mass which is disposed opposite and faces the electrode 22 is provided with a recess or cavity which is complementary to and in face to face relationship with the lateral extension or hemisphere 25 of the electrode. The plane of the inertial mass is approximately parallel to the plane of the electrode and the casing end walls. The free space within the casing contains loosely packed carbon granules 23 which as to quantity and resistance are selected in accordance with standard design practice.

A diaphragm 30 is affixed to the end wall 24 of the casing whereby the acoustic energy impinging upon the diaphragm is efficiently transmitted to the casing in a direction transverse to the end walls and the plane of the inertial mass. The diaphragm may be of any standard type or design and is covered by a mouthpiece 31 disposed in front and spaced from the diaphragm opposite the casing. The mouthpiece as illustrated has a number of openings 32 extending from face to face so that any water which enters or is present between the diaphragm and the mouthpiece may be easily expelled. Likewise the diaphragm can be provided with drain holes either for use with or without the illustrated mouthpiece. The casing, diaphragm and mouthpiece are assembled within a support housing 33 which is open at the end facing the mouthpiece and with its opposite end spaced from the rear end wall of the casing 20. The above enumerated component parts of the microphone may be individually supported within the housing or as has been shown the mouthpiece prevented from moving out of the housing by an abutment 34 which retains its. The outer peripheral edges of the diaphragm tightly abut the inner face 35 of the mouthpiece and it is held there against by a spacer 36 which has an annular portion 37 in abutting relationship with the edge 38 of the diaphragm. The spacer is circular in cross-section and has a passage 39 there-through from face to face. The passage is enlarged at one end so as to allow free movement of the operating portion of the diaphragm and thereby also form the annular portion 37 abutting the diaphragm edge. The casing 20 is supported by the diaphragm and is disposed within the smaller portion of the passage 39 and spaced from the walls of the passage.

With the microphone thusly assembled it is relatively simple to describe its operation. The hemispheric portion 25 of the electrode and the complementary recess of the inertial mass are employed so that the microphone can be used in any physical position as for example upside down. Since the carbon granules are not tightly packed and need not entirely fill the space within the casing then, when the microphone is upside down at least a portion of the electrode, namely the hemisphere, will be in contact with the carbon. Sound or acoustical vibrations impinge upon the diaphragm and are transmitted to the casing which is free to move and which is set in motion in a direction crosswise of its end walls. The

inertial mass 21 due to its large mass resists moving in the direction of motion of the casing and tends to remain stationary since it is supported by springs or a resilient complaint material. This in effect causes a relative displacement between the electrode and the inertial mass since the mass can remain stationary while the casing responds to the movement of the diaphragm and, therefore, the carbon granules disposed between the electrode and the mass are either compressed or allowed to separate under the action of the casing. This changes the resistance between the electrode and the mass through the carbon in accordance with the relative motion of the mass and the casing. This change or alternating resistance is converted into a corresponding electrical signal by a D.C. supply (battery 40) and the primary of a transformer 41 which are connected in series with the signal leads or wires 28 and 29 to form a complete loop circuit consisting of the electrode 22, the carbon granules 23, the inertial mass 21, the transformer 41 primary and the battery 40. Only an alternating signal appears across the secondary of the transformer 41 since the battery or D.C. component is effectively blocked and this output signal may then be applied to any desired utilization circuit such as a transmitter or projector by suitable circuitry not shown.

Under certain conditions it is necessary to employ a microphone with a much higher output so that the embodiment illustrated in FIG. 4 should be employed. This microphone is identical in most respects with the one previously described except that a three terminal or electrode system is substituted with its appropriate circuitry. Two identical electrodes 50 and 51 are disposed in face to face spaced relation one located at and abutting each end wall of the casing with their hemispheric portions directed toward the center of the casing. The inertial mass 52 is located approximately between the electrodes and has a pair of recess 53 and 54 each disposed on an opposite face of the mass and aligned with the hemispheric portion of the facing electrode. The composition of the component parts may be identical with those described for the embodiments of FIGS. 2 and 3. The mass, and the electrodes are supported in the same manner as previously described. A wire is electrically connected to each of the electrodes and the mass. Each of the wires 55, 56 and 57 is sealed to and passes through the casing. The electrode connecting wires 55 and 57 are connected to the outer terminals of the primary of transformer 58 while the inertial mass wire 56 is connected through a battery 59 to the primary center tap. Since the current passing through one electrode is out of phase with the other, one section of the transformer primary can be wound so that the resultant fields produced in both of the primary windings are additive and the secondary output is thereby increased. The movement and operation of this embodiment is identical with the first described embodiment.

It should be noted at this point that the principle involved in this invention does not restrict its use to carbon granules and other transducer-like elements easily substituted. By way of example, FIG. 5 illustrates still another embodiment wherein the same electrode and inertial mass are employed except that an electrostrictive element is substituted for the carbon granules. The transducer element 60 may be a bar of barium titanate or other suitable electrostrictive material which has its opposite end faces coated with a layer of electrically conducting material and which has to be polarized between these faces by any of a number of standard techniques. The electrically coated ends 61 and 62 of the element abut approximately centrally respectively the electrode 63 and the inertial mass 64. The element can be bonded to the electrode or supported in any suitable manner. If the bond and the electrode are electrically conducting then the signal lead 65 can be connected to the electrode otherwise it must contact the conductive coating 61. A similar physical situation exists for the other end coating 62

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and the inertial mass and the signal lead 66 is shown here as connected to the coating 62. As the ceramic 60 is alternately compressed and tensioned between the electrode and the biased inertial mass a signal voltage is developed across the coated surfaces 61 and 62 in accordance with the vibratory displacement of the casing and diaphragm. This principle is well known in the art and the resultant signal likewise applied to a utilization circuit.

In accordance with this invention the microphone may be fabricated quite easily, made extremely small (button type microphone) and even employed as a hydrophone due to its watertight construction. Further this rigidly encased stationary mass concept may be applied to dynamic, crystal and condenser microphones.

It will be understood that various other changes in the details, materials and the arrangement of parts which have been herein described and illustrated in order to explain the nature of this invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

I claim:

1. A compact, water-tight microphone suitable for use with an underwater swimmer's mask which comprises a support, a diaphragm carried by said support and movable approximately back and forth rectilinearly in response to vibratory impulses impinging on said diaphragm, a closed integral, water-tight casing of a non-electrically conducting material attached to an approximately centrally located on said diaphragm for rectilinear movement therewith, an inertia element within said casing having an electrically conducting face and spaced from the walls of the casing, compliant resilient means within said casing supporting said element in spaced relation to the walls of the casing for rectilinear vibratory movement in the direction of vibration of said diaphragm in the casing and biased into an intermediate position in its path of vibratory movement, an electrically conducting member within the casing and spaced from said element in the direction of vibratory movement of said element, loose carbon granules in said casing between and abutting said conducting face of said element and said conducting member and surrounding said element filling the space between said walls of said casing and said element while providing a conducting path between them, and a utilization circuit having said element and member as a part thereof, whereby when said casing is vibrated rectilinearly by said diaphragm the variable pressure of said element on said granules will vary the resistance of said circuit with a frequency corresponding to and an amplitude proportional to those of the vibration of said diaphragm.

2. A compact, water-tight microphone suitable for use with an underwater swimmer's mask which comprises a support, a diaphragm carried by said support and movable approximately back and forth rectilinearly in response to vibratory impulses impinging on said diaphragm, a closed, water-tight casing attached to and approximately centrally located on said diaphragm for rectilinear movement therewith, an inertia element within said casing having an electrically conducting face and spaced from the walls of the casing, electrically conductive spring means in electrical contact with said electrically conducting face, within said casing supporting said element in spaced relation to the walls of the casing for rectilinear vibratory movement in the direction of vibration of said diaphragm in the casing and biased into an intermediate position in its path of vibratory movement, an electrically conducting member within the casing and spaced from said element in the direction of vibratory movement of said element, loose carbon granules in said casing between

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and abutting said conducting face of said element and said conducting member and providing a conducting path between them, and a utilization circuit having said element and member as a part thereof, whereby when said casing is vibrated rectilinearly by said diaphragm the variable pressure of said element on said granules will vary the resistance of said circuit with a frequency corresponding to and an amplitude proportional to those of the vibration of said diaphragm.

3. The microphone according to claim 2 wherein said element has a recess in said conducting face and said electrically conducting member is provided with a lateral extension extending in a direction toward said conducting face and complementary to said recess.

4. The microphone according to claim 3 wherein said recess is a hemispherical cavity and said extension is a hemisphere.

5. An apparatus for converting the vocal speech of an underwater swimmer into a corresponding electrical signal which comprises in combination an underwater swimmer's face mask which is provided at its inner portion with a cavity that is disposed in front of a swimmer's mouth, said mask tightly abutting the face of said swimmer whereby said cavity is watertight when said mask is worn, means for supplying breathing air into said cavity and means for expelling air from said cavity, a support, a diaphragm carried by said support and movable approximately back and forth rectilinearly in response to vibratory impulses impinging on said diaphragm, a closed, integral water-tight casing of a non-electrically conducting material attached to and approximately centrally located on said diaphragm for rectilinear movement therewith, an inertia element within said casing having an electrically conducting face and spaced from the walls of the casing, compliant resilient means within said casing supporting said element in spaced relation to the walls of the casing for rectilinear vibratory movement in the direction of vibration of said diaphragm in the casing and biased into an intermediate position in its path of vibratory movement, an electrically conducting member within the casing and spaced from said element in the direction of vibratory movement of said element, loose carbon granules in said casing between and abutting said conducting face of said element and said conducting member and surrounding said element, filling the space between said walls of said casing and said element while providing a conducting path between them, said microphone carried by said mask and disposed in said cavity with said diaphragm opposite and spaced from the mouth of said swimmer.

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